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RESOR - **R**enewable **E**nergy **So**urces as a Chance for Development for the **R**ural Areas

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Module 8: Hydroelectric Energy

by Defoin

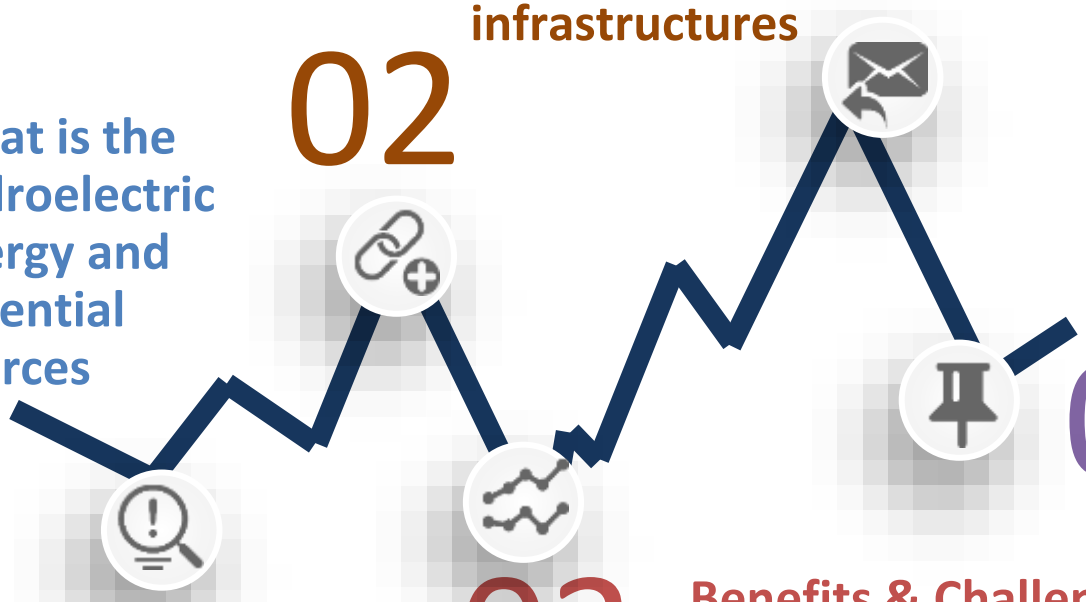
Presentation Content

01 What is the hydroelectric energy and potential sources

02 Hydroelectric infrastructures

03 Benefits & Challenges & Environmental Impacts of Hydroelectric energy

04 Economics & Case study



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Hydroelectric energy

"Hydroelectric energy is generated by converting kinetic energy from water into electrical energy. To harness this power, enormous hydroelectric infrastructures are built to extract maximum power from this renewable emission-free, local resource." (Source: Iberdrola.com)

Potential sources (I)

Diverting the stream: With this method, the water is diverted from the current to a pipeline that carries the water to the hydropower plant. They depend highly on the size of the current at that specific moment, porducing highly variable amounts of energy.

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Potential sources (II)

Intercepting the stream: By building a dam, the stram of the river is interrumped, therefore raising its level and slowing the speed of the flow. Narrow parts of the stream are used.

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Hydroelectric infrastructures

Hydropower plants

Electric energy cannot be stored >> **prevision** of power needed

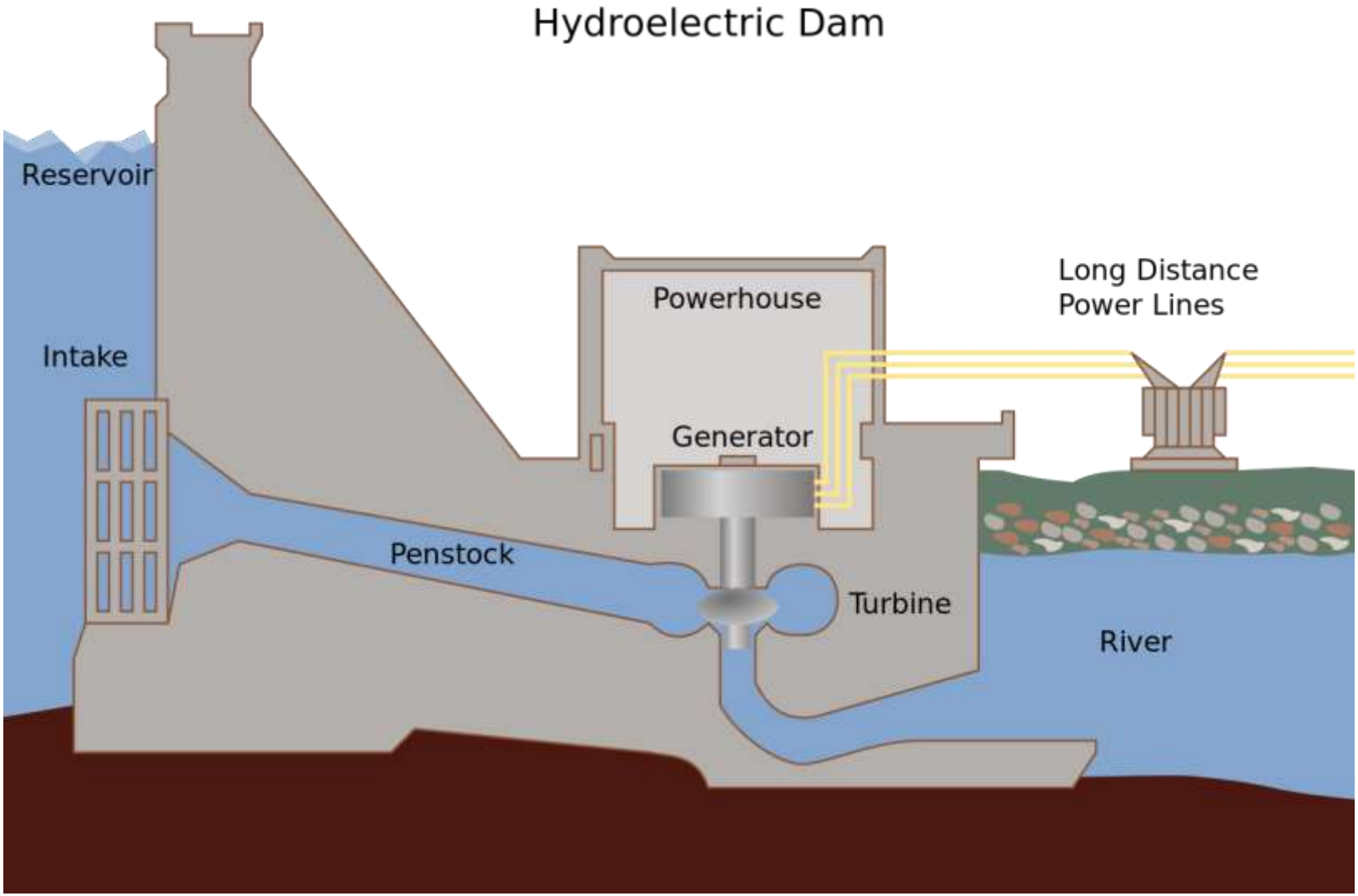
Power plants need to adapt the amount of power they are producing >> **flexibility**

Hydropower plants

A typical hydropower plant has 3 parts:

- a power plant where the electricity is produced,
- a dam that can be opened or closed to control water flow,
- a reservoir where water is stored.

How does a hydropower plant work?



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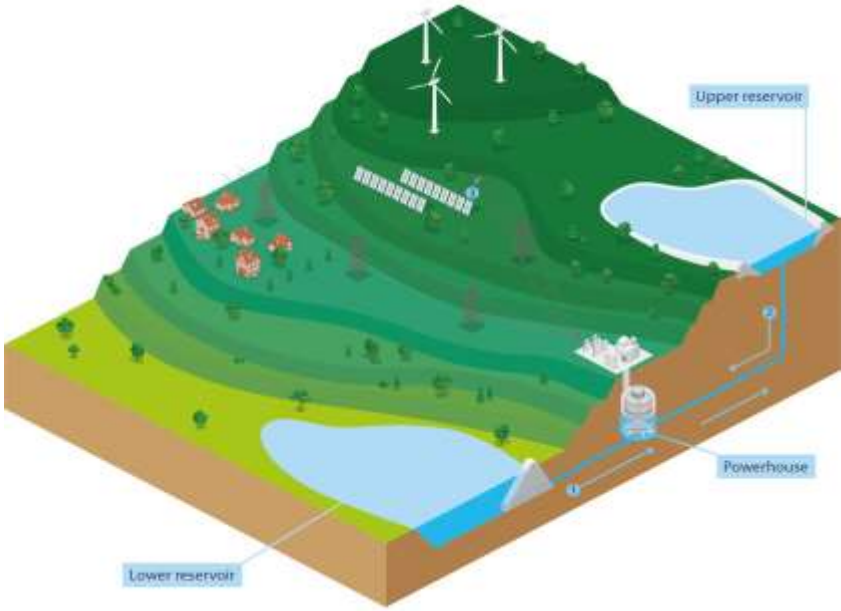
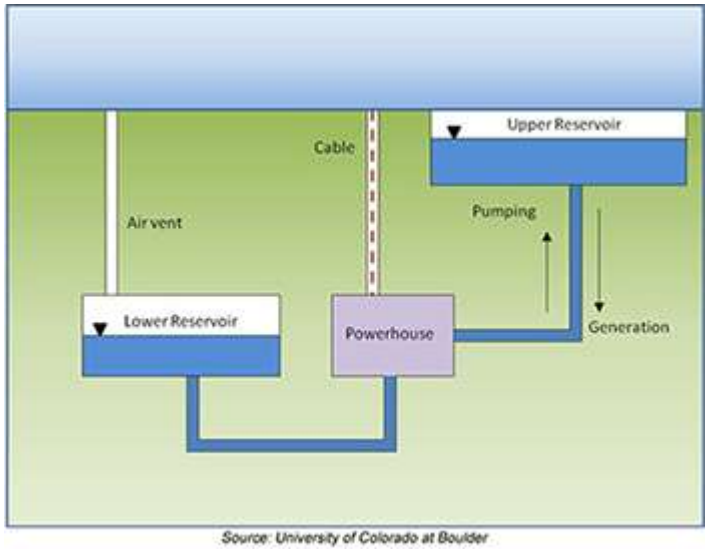
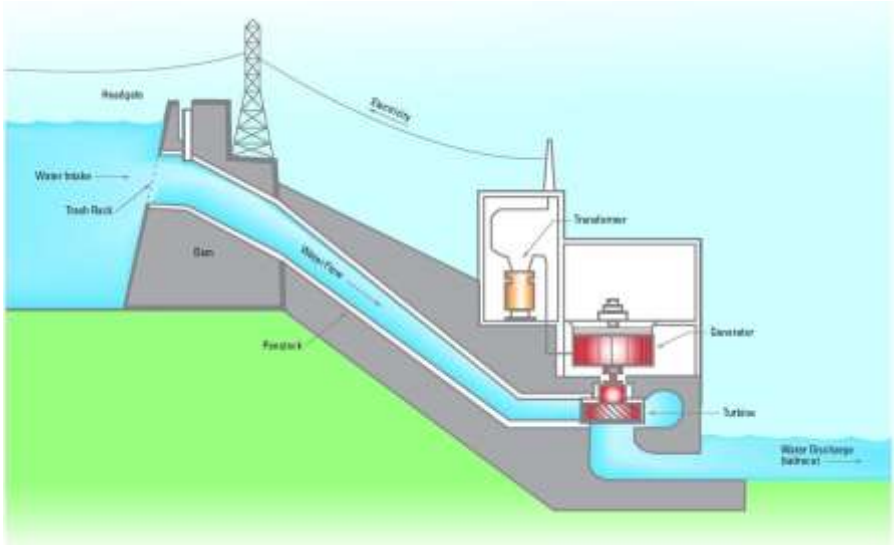
Types of hydropower plants

- Exterior plants
- Underground plants
- Plants in a well





Source: University of Colorado at Boulder



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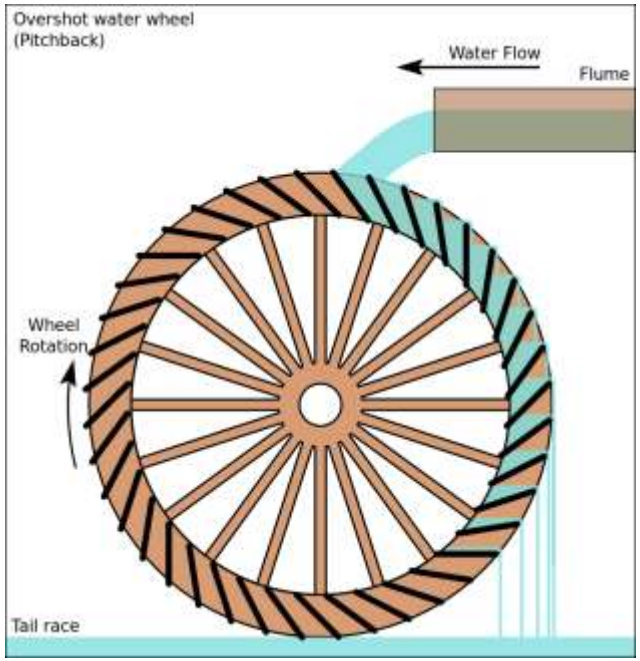
Water wheels

Water wheels were invented in the 1st century BC >> revolutionary invent.

Their role was to convert water power into different forms of power, similar use to windmills. Those uses could be from milling flour or grinding wool to hammering mineral ores.



Water wheels can be divided into to types:

- horizontal
- vertical

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High Speed Commercial Turbines

At the end of the 19th century **Lester Pelton** made such modifications to the water wheels that he set off the development of the water turbines. A turbine is the element that uses the kinetic energy of the water to produce a rotation movement that, once transferred to a generator, it turns into electric power.

The turbines can be classified into two different categories: action or reaction turbines.

- Impulse turbines: They only use the flow speed of the water to turn. This means the use only the height to the turbine.
- Reaction turbines: They not only use the height to the turbine, but they also make use of the difference in height from the turbine to the release pipe.

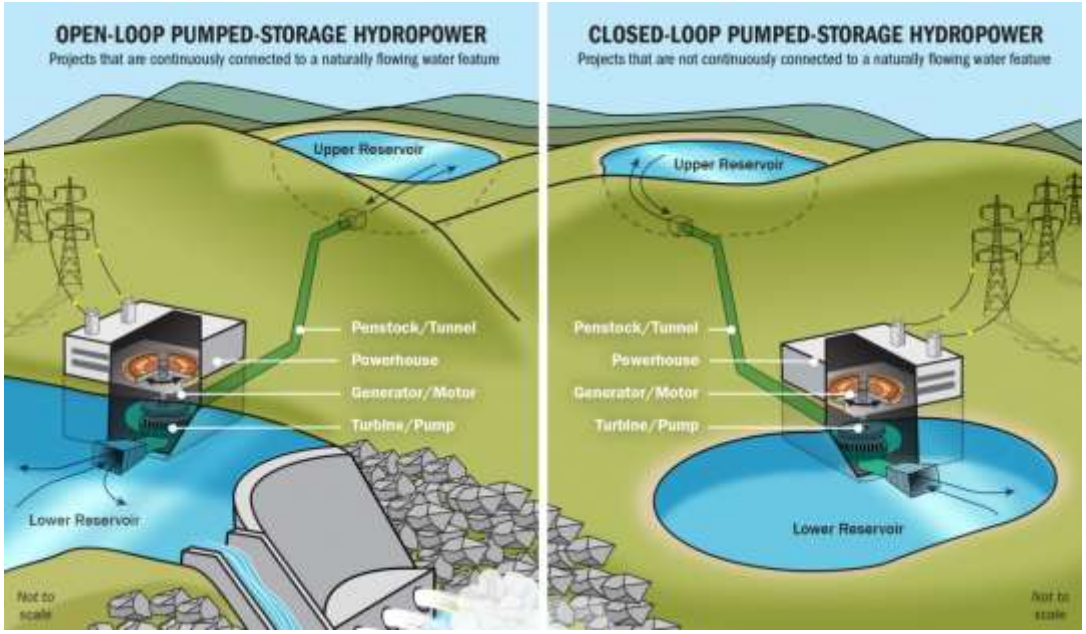
Head and flow

Hydropower all comes down to head and flow. The amount of power, and therefore energy that you can generate is proportional to the **head** and the **flow:**

- **Head** is the change in water levels between the hydro intake and the hydro discharge point.
- The **flow** is the volume of water, expressed as cubic feet or cubic meters per second (m3/sec), passing a point in a given amount of time.

Storing energy

Hydroelectric pumping technology is the most efficient system that allows to store energy in a large-scale today.



Pumped-storage hydropower (PSH) is a type of hydroelectric energy storage. It is a configuration of two water reservoirs at different elevations that can generate power (discharge) as water moves down through a turbine; this draws power as it pumps water (recharge) to the upper reservoir.

Power plant efficiency

The hydroelectric system needs be as efficient as possible, and we need to take into account the following factors:

- That the entry, exit and conducting of the water is efficient, and few kinetic energy is lost.
- That the turbine is efficient.
- That the electric generator is efficient.
- That the transmition from the power plant to where the energy is going to be consumed is optimized.

A home-made water turbine (I)

To do a home-made water turbine we will need the following materials:

- An old bike
- Wheel from a bike
- Chain
- Pedal
- Car generator
- Plastic sheeting (spoons or cups)

A home-made water turbine (II)

Then we follow these steps:

1. Remove the front wheel from the bike.
2. Remove the chain from the bicycle's pedals.
3. Weld or mount the car generator or alternator to the underside of the pedals, so that when the chain is wrapped around the alternator's pulley, it is centered
4. Raise the bike's seat all the way up.
5. Saw several dozen plastic balls into halves.
6. Screw the plastic ball halves or small plastic cups onto the bicycle's rear wheel, spaced about two inches apart, and all in the same direction.
7. Place the bike into a creek or source of moving water upside down so that the seat is in the water. The cups should be facing the water current so that they push the wheel

If the water current is strong enough, the wheel will keep turning and will generate 12 volts of electricity at a few amps. Wire the alternator to charge batteries on shore or to power equipment.

- It’s a clean fuel source renewed by snow and rainfall.
- Can supply large amounts of electricity
- Dams also prevent fish such as salmon from swimming upstream to spawn.
- The environmental impacts of hydroelectric power can be mitigated and remain low compared to other fossil fuels and nuclear energy.

Advantage

Disadvantages

- Change migration patterns and hurt fish populations.
- Cause low dissolved oxygen levels in the water, which is harmful to river habitats.
- Pollution that occurs during the construction of these massive power plants, power lines, etc.
- Building hydroelectric power plants in general is expensive
- Electricity generation and energy prices are directly related to how much water is available
- Limited reservoirs.

Environmental impacts of using hydroelectric energy

Disrupting the natural ecology of rivers

Damaging forests and biodiversity

Releasing a high amount of greenhouse gases

Disrupting food systems and agriculture

Deteriorating water quality

Human costs

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Economics of the small-scale hydroelectric energy systems

There is a formula to describe the relationship between costs and the power and head of a small hydropower scheme (Ogayar and Vidal, 2009):

COST (per kW) = αP1-βHβ1

P is the power in kW of the turbines;

H is the head in metres;

α is a constant; and

β and β1 are the co-efficients for power and head, respectively.

1. **Affordable energy:** Small hydropower, where a suitable site exists, is often a very cost-effective electric energy generation option.
2. **Rural development:** Small hydropower can be a cost-competitive option for rural electrification for remote communities in developed and developing countries and can displace a significant proportion of diesel-fired generation.
3. **Cheap material:** The powerhouse contains most of the mechanical and electrical equipment and is made of conventional building materials although in some cases this maybe underground
4. **Save money:** For small hydropower plant, ambitious refurbishments can be envisaged

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The Robert Moses Niagara Power Plant

https://www.nypa.gov/power/generation/niagara-power-project

The plant has 13 turbines. It shares a forebay with a capacity of 740 million gallons of water providing up to 2.6 million kilowatts of clean electricity

Now Niagara is the biggest electricity producer in New York State, generating enough power to light 24 million 100-watt bulbs at once. This low-cost electricity saves the state's residents and businesses hundreds of millions of dollars a year, according to the New York Power Authority.

It currently helps to protect more than 27,200 jobs in the western New York region.

NYPA also has a substantial impact on the tourism industry in western New York. Power Vista is the visitors' center for the Niagara plant and has been considered a must-see destination for tourists from all over the U.S. and the world for more than 50 years. In 2013 it welcomed its 7 millionth visitor.

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